PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 140.2	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. PCT/CA2004/001888	International filing date *(day/month/year)* 28 October 2004 (28-10-2004)	Priority date *(day/month/year)* 28 October 2003 (28-10-2003)
International Patent Classification (IPC) or national classification and IPC IPC(7): D21C 9/10, D21D 5/00		
Applicant CENTRE DE RECHERCHE INDUSTRIELLE DU QUEBEC ET AL		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets, including this cover sheet.

3. This report is also accompanied by ANNEXES, comprising:

   a. [X] *(sent to the applicant and to the International Bureau)* a total of 11 sheets, as follows:

      [X] sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).

      [ ] sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.

   b. [ ] *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) ,containing a sequence listing and/or tables related thereto, in électronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

[X] Box No. I	Basis of the report
[ ] Box No. II	Priority
[ ] Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
[ ] Box No. IV	Lack of unity of invention
[X] Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
[ ] Box No. VI	Certain documents cited
[ ] Box No. VII	Certain defects in the international application
[ ] Box No. VIII	Certain observations on the international application

Date of submission of the demand 16 May 2005 (16-05-2005)	Date of completion of this report 31 August 2005 (31-08-2005)
Name and mailing address of the IPEA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001(819)953-2476	Authorized officer James McCarthy (819) 994-0411

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/CA2004/001888

Box No. I Basis of the report

1. With regard to the **language**, this report is based on:

   [X] the international application in the language in which it was filed

   [ ] a translation of the international application into , which is the language of a translation furnished for the purposes of:

   - [ ] international search (Rules 12.3(a) and 23.1(b))
   - [ ] publication of the international application (Rule 12.4(a))
   - [ ] international preliminary examination (Rules 55.2(a) and/or 55.3(a))

2. With regard to the **elements** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report):*

   [ ] the international application as originally filed/furnished

   [X] the description:

[X]	pages	4-9 and 11-16		as originally filed/furnished
[X]	pages*	1-3, 3A, 3B, 10 and 10A	received by this Authority on	13 June 2005
[ ]	pages*		received by this Authority on	

   [X] the claims:

[ ]	pages			as originally filed/furnished
[X]	pages*	21-24	as amended (together with any statement) under Article 19	
[ ]	pages*		received by this Authority on	
[ ]	pages*		received by this Authority on	

   [X] the drawings:

[X]	pages	1/5-5/5		as originally filed/furnished
[ ]	pages*		received by this Authority on	
[ ]	pages*		received by this Authority on	

   [ ] a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing.

3. [X] The amendments have resulted in the cancellation of:

   - [ ] the description, pages
   - [X] the claims, Nos. 14 and 15
   - [ ] the drawings, sheets/figs
   - [ ] the sequence listing *(specify):*
   - [ ] any table(s) related to sequence listing *(specify):*

4. [ ] This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

   - [ ] the description, pages
   - [ ] the claims, Nos.
   - [ ] the drawings, sheets/figs
   - [ ] the sequence listing *(specify):*
   - [ ] any table(s) related to sequence listing *(specify):*

* *If item 4 applies, some or all of those sheets may be marked "superseded."*

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/CA2004/001888

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-13	YES
	Claims	NONE	NO
Inventive step (IS)	Claims	1-13	YES
	Claims	NONE	NO
Industrial applicability (IA)	Claims	1-13	YES
	Claims	NONE	NO

2. Citations and explanations (Rule 70.7)

The examiner has not identified any prior art which teaches a method or apparatus for estimating an optimal dosage of bleaching agent to be used in a pulp production process by employing a predictive model which uses wood chip property data, an initial bleaching agent dosage value, and a required brightness value as defined by independent Claims 1 and 9 of the present application. Accordingly, Claims 1-13 meet the criteria for novelty and inventive step (*PCT Article 33(2)* and *PCT Article 33(3)*).

The subject matter of Claims 1-13 comply with *PCT Article 33(4)* as the claimed invention is considered to be industrially applicable since according to its nature, it can be made or used (in the technological sense) in industry.

10/577434
PCT/CA2004/001888

13 June 2005 (13-06-2005)

IAP20 Rec'd PCT/PTO 27 APR 2006

METHOD AND APPARATUS FOR ESTIMATING AN OPTIMAL DOSAGE OF BLEACHING AGENT TO BE USED IN A PROCESS FOR PRODUCING PULP

Field of the invention

The present invention relates to the field of pulp and paper process automation, and more particularly to methods for estimating and controlling optimal dosage of bleaching agent to be used in a process for producing pulp of a required brightness value from wood chips.

Background of invention

Thermomechanical pulp properties and quality are influenced by two types of variables: feed material (chips) and process (refiner). Over the years, many researchers have underscored the impact of the stability of the refiner operation for the production of constant pulp quality, as mentioned by Strand, B. C. in "The Effect of Refiner Variation on Pulp Quality", International Mechanical Pulping Conference, Helsinki, Finland, Proceedings, 125-130 (1995). However, variations of the process itself are mainly related to variations in the raw material feeding the system as, mentioned by Wood, J. A. in "Chip Quality Effects in Mechanical Pulping – a Selected Review", 1996 Technical Association for the Pulp and Paper Industry (TAPPI) Pulping Conference Nashville, TN, Proceedings, 491-497 (1996). In particular, pulp brightness is considered as an important quality requirement, as discussed by Dence, C. W. et al. in "Pulp Bleaching – Principles and Practice", Technical Association for the Pulp and Paper Industry (TAPPI) Press, Atlanta GA, 457-490 (1996). A method for estimating surface moisture of wood chips is disclosed by Ding, F. et al. in "Wood Chip Physical Quality Definition and Measurement", *IMPC Proceedings,* June 2-5, Québec, Canada, 367-373 (2003). A wood chip optical inspection apparatus for measuring a number of optical properties as well as moisture content is disclosed in U.S. Patent no. 6,175,092 B1 issued on January 16, 2001 to the present assignee. A system and process for automatically and simultaneously controlling the solution viscosity and degree of brightness of a pulp during a bleaching process is disclosed in U.S. Patent no. 4,013,506 issued on March 22, 1977, which employs a sequence of chlorination, hypochlorite and chlorine dioxide bleaching reagents, wherein the pulp is monitored during the bleaching sequence by employing an optical device. A method of bleaching comminuted cellulosic fibrous material having cleanliness which varies significantly over time is disclosed in International PCT published application no. WO 95/28517A1, wherein brightness, color, or lignin content of the pulp is sensed prior to treatment in a first bleaching stage, the quantity of first

bleaching chemical added to the first stage being controlled in response to the selected parameter to achieve a target brightness increase for the first stage, the sensing and quantity control steps being then repeated for a second and subsequent stages. In Canadian published patent application no. 2,265,182, there is disclosed a system and a method for obtaining a substantially constant percentage of delignification of pulp across a first bleaching/delignifying stage, which make use of a computer coupled to a distributed control system (DCS) and/or database for acquiring data related to pulp properties prior to entrance of the pulp into a bleaching tower and data related to conditions within the bleaching tower. The computer is used to process the data using a kinetic model to predict reagent consumption, change in kappa number, and change in brightness to determine a bleaching/delignifying reagent flow rate required to obtain the substantially constant percentage of delignification of the pulp across the first bleaching/delignifying stage, and a pulp tracking algorithm to calculate changes in kappa number at the bleaching tower outlet based on pulp flow and temperature, whereby the bleaching/delignifying reagent flow rate is controlled automatically by the DCS. In Canadian published patent application there is disclosed a device and a method for measuring the bleach requirement and bleachability of pulp in a pulp mill, involving a series of optical measurements of pulp samples transferred in an off-line reaction chamber.

Summary of invention

A main object of the methods, apparatus and system according to the invention is to estimate the optimal dosage of bleaching agent for the purpose of control thereof in a pulp production process, by modeling the relationship between the quality of the chips feeding the process with an important pulp and paper resulting property, namely pulp brightness. In particular, the model is used to evaluate the minimum charge of peroxide required to reach certain level of pulp brightness according to possible chips properties fluctuations, in order to minimize the cost and environmental impact of the bleaching operation.

According to the above mentioned object, from a broad aspect of the invention, there is provided a method for estimating an optimal dosage of bleaching agent to be used in a process for producing pulp of a required brightness value from wood chips. The method comprises the step of: i) estimating a set of wood chip properties characterizing said wood chips to generate corresponding wood chip properties data, said set including reflectance-related properties; said method being characterized by further comprising the steps of: ii) providing an initial dosage value of said bleaching agent; and iii) feeding said

wood chip properties data and said bleaching agent dosage value at corresponding inputs of a predictive model for generating predicted brightness value of pulp to produce from said wood chips, to estimate the optimal bleaching agent dosage for which said predicted brightness value substantially reaches said required brightness value, wherein the predictive model estimates the optimal bleaching agent dosage by performing the steps of: a) comparing the brightness predicted value with the required brightness value to generate error data; b) optimizing the bleaching agent dosage value to minimize the error data; and c) repeatedly generating predicted brightness value and performing said steps a) and b) with the optimized bleaching agent dosage value until the predicted brightness value substantially reaches the required brightness value, to estimate said optimal bleaching agent dosage.

According to the same object, from another aspect of the invention, there is provided a method of controlling the bleaching of pulp in a pulp production process on the basis of the optimal bleaching agent dosage estimated according to the above mentioned estimation method, said pulp production process including, between said steps i) and iii), at least one processing step including a step of refining said wood chips to produce refined wood chips. The control method comprises the step of: d) adding bleaching agent to said refined wood chips according to said optimal bleaching agent dosage to produce said pulp.

According to the same object, from another aspect of the invention, there is provided a method of controlling the bleaching of pulp in a pulp production process on the basis of the optimal bleaching agent dosage estimated according to the above mentioned estimation method, said pulp production process including, between said steps i) and iii), at least one processing steps including a step of refining said wood chips to produce refined wood chips. The control method comprising the step of: d) estimating a resulting brightness value of the pulp according to a time delay following said predicted brightness value generation; e) comparing said predicted brightness value with said resulting brightness value to generate further error data; f) further optimizing said bleaching agent dosage value to minimize said further error data; and g) adding bleaching agent to said refined wood chips according to said further optimized bleaching agent dosage to produce said pulp.

According to the same object, from another aspect of the invention there is provided an apparatus for estimating an optimal dosage of bleaching agent to be used in a process for producing pulp of a required brightness value from wood chips. The apparatus comprises means for estimating a set of wood chip

properties characterizing said wood chips to generate corresponding wood chip properties data, said set including reflectance-related properties. The apparatus is characterized by further comprising: data processor means implementing a predictive model receiving at corresponding inputs thereof said wood chip properties data and an initial bleaching agent dosage value for generating predicted brightness value of pulp to produce from said wood chips, to estimate the optimal bleaching agent dosage for which said predicted brightness value substantially reaches said required brightness value, wherein said predictive model includes means for comparing the brightness predicted value with the required brightness value to generate error data, and means for optimizing said bleaching agent dosage value to minimize said error data.

According to the same object, from another aspect of the invention there is provided a system of controlling the bleaching of pulp in a pulp production process on the basis of the optimal bleaching agent dosage estimated by the above mentioned apparatus, said pulp production process including at least one processing steps including a step of refining said wood chips to produce refined wood chips. The control system comprises means for adding bleaching agent to said refined wood chips according to said optimal bleaching agent dosage to produce said pulp.

According to the same object, from another aspect of the invention there is provided a system for controlling the bleaching of pulp in a pulp production process on the basis of the optimal bleaching agent dosage estimated by the above mentioned apparatus, said pulp production process including at least one processing steps including a step of refining said wood chips to produce refined wood chips. The control system comprises means for estimating a resulting brightness value of the pulp according to a time delay following said predicted brightness value generation by said predictive model; means for time delaying said predicted brightness value according to said time delay; means for comparing said delayed predicted brightness value with said resulting brightness value to generate further error data; said predictive model further optimizing said bleaching agent dosage value to minimize said further error data; and means for adding bleaching agent to said refined wood chips according to said further optimized bleaching agent dosage to produce said pulp.

Brief description of the drawings

The methods, apparatus and system according to the present invention will be described in detail with reference to the accompanying drawings in which:

Fig. 1 is a graph showing relative importance index of independent variables according to PLS analysis;

Fig. 2 is a graph showing coefficient of correlation for dependent variables by PLS analysis;

Fig. 3 is a graph representing observed and predicted values for ISO brightness; and

Fig. 4 is a block diagram of a bleaching agent control system according to a first embodiment of the invention, which includes an estimation apparatus based on a neural network-based predictive model;

Fig. 3 presents observed and predicted values for the ISO brightness. These results show that the model is able to predict adequate values for this optical property. Brightness ranging from 43.79% to 80.2% was measured on the bleached pulps.

A neural network-based predictive model that can be used to carry out the method according to the invention will now be described in reference to Fig. 4. It is to be understood that any appropriate modeling technique such as neural network, PLS, Model Predictive Controller (MPC), regression, state space matrix, FRI, fuzzy logic, genetic algorithm, or a combination thereof can be used to obtain a predictive model for the purpose of the present invention. Some of those known predictive modeling techniques are discussed by Quian, X. et al. in "Mechanistic Model for Predicting Pulp Properties from Refiner Operating Conditions" Association for the Pulp and Paper Industry (TAPPI) Journal, Atllanta, GA, 78 (4) (1994); by Qian, Y. et al. in "Fuzzy Logic Modeling and Optimization of a Wood Chip Refiner" Association for the Pulp and Paper Industry (TAPPI) Journal, Atllanta, GA, 77 (2) (1995), and by Qian, Y. et al. in "Modeling a Wood-Chip Refiner Using Artificial Neural Networks, Association for the Pulp and Paper Industry (TAPPI) Journal, Atllanta, GA, 78 (6): 167-174 (1995). The predictive model generally designated at 10 and as readily implemented in a data processing device such as a computer (not shown) provided on the bleaching agent dosage estimating apparatus and bleaching control system represented in Fig.4, preferably includes a neural network 12 that was previously trained according go to the experimentally obtained data on wood chip properties and on dosage of said bleaching agent as described above, i.e. over the nine (9) remaining database columns consisting of eight (8) inputs identified by PLS method as shown in Fig. 1, and one output, namely pulp brightness as shown in Fig. 3. Such known neural network and associated training approach are discussed by Laperrière L. et al. in "Modeling and simulation of pulp and paper quality characteristics using neural networks" Association for the Pulp and Paper Industry (TAPPI) Peer-Reviewed Paper / Solutions for People, Processes and Paper, Atlanta, GA, Vol. 84, no. 10 (2001). After a few unsuccessful training trials, it was noticed that the input NaOH is always a ratio of the input H2O2, so it was eliminated from the training set. Out of the available (506) training lines, a selected number (96) were removed (about 20%) and injected back to the trained network for validation. Different sets of the removed 20% were tested and gave similar results. The final configuration was a 7-5-1 neural network (7 inputs, 5 hidden neurons and 1 output) as designated at 12 in Fig. 4. Training was stopped

after an average absolute mean error of 5% was reached between the neural network prediction and the training output brightness value for each of the 506 lines. The value of 5% was chosen by taking two factors into consideration: 1) reliability of the output measurements: the experimental error related to the brightness value is about 3%, i.e. ±0.5 brightness points in the experimental span

